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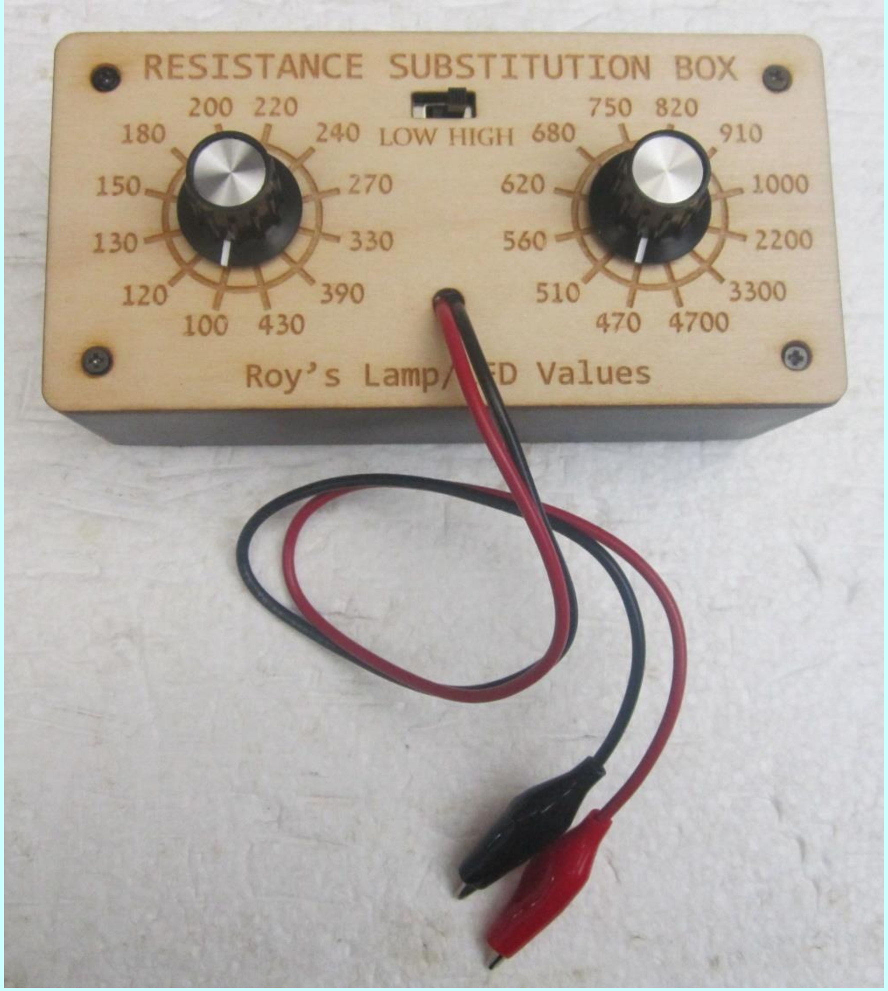
Resistor Substitution Box



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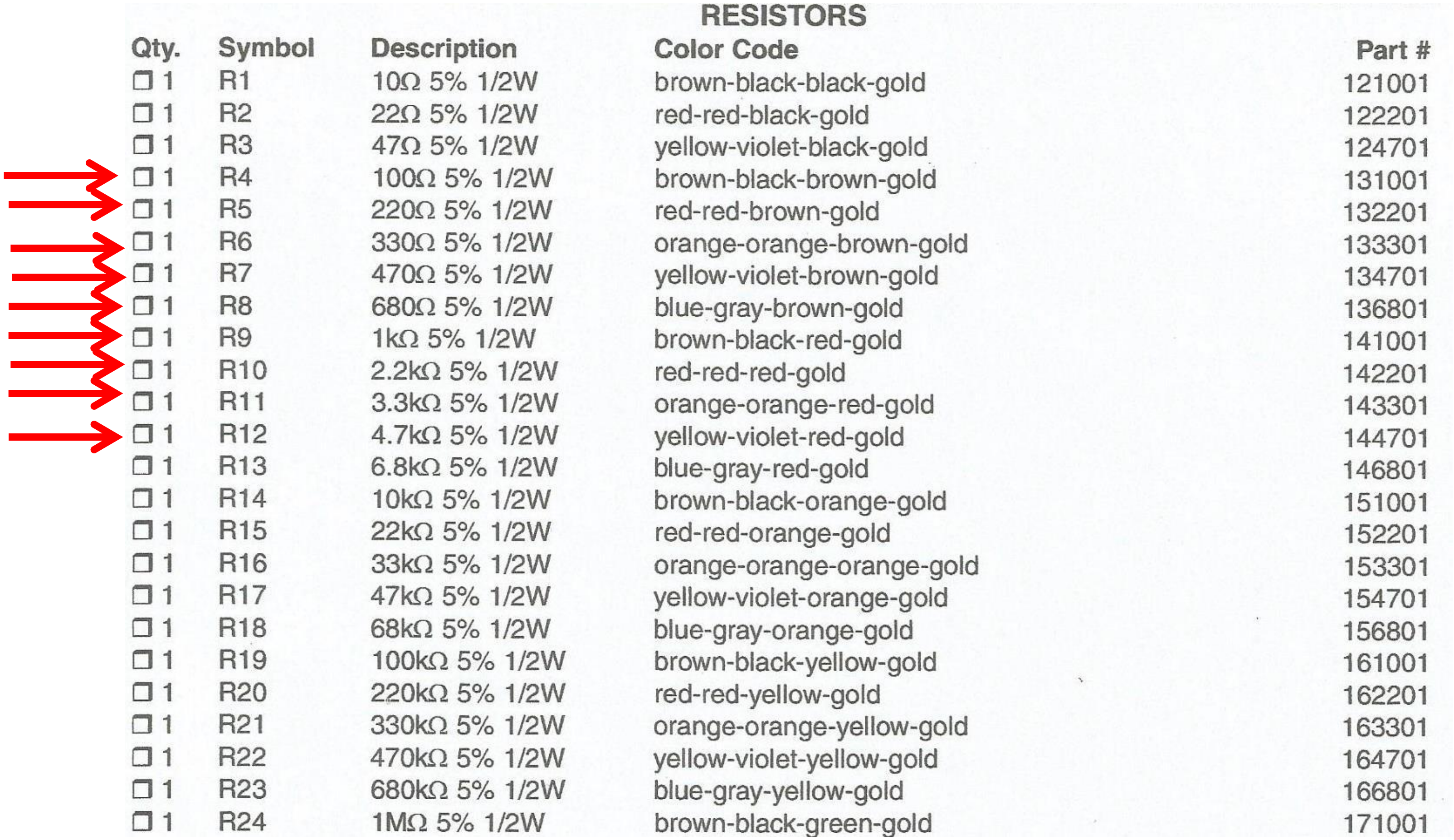
Remove these resistors from the bag



RESISTORS

	Qty.	Symbol	Description	Color Code	Part #
	☐ 1	R1	10Ω 5% 1/2W	brown-black-black-gold	121001
	☐ 1	R2	22Ω 5% 1/2W	red-red-black-gold	122201
	☐ 1	R3	47Ω 5% 1/2W	yellow-violet-black-gold	124701
→	☐ 1	R4	100Ω 5% 1/2W	brown-black-brown-gold	131001
→	☐ 1	R5	220Ω 5% 1/2W	red-red-brown-gold	132201
→	☐ 1	R6	330Ω 5% 1/2W	orange-orange-brown-gold	133301
→	☐ 1	R7	470Ω 5% 1/2W	yellow-violet-brown-gold	134701
→	☐ 1	R8	680Ω 5% 1/2W	blue-gray-brown-gold	136801
→	☐ 1	R9	1kΩ 5% 1/2W	brown-black-red-gold	141001
→	☐ 1	R10	2.2kΩ 5% 1/2W	red-red-red-gold	142201
→	☐ 1	R11	3.3kΩ 5% 1/2W	orange-orange-red-gold	143301
→	☐ 1	R12	4.7kΩ 5% 1/2W	yellow-violet-red-gold	144701
	☐ 1	R13	6.8kΩ 5% 1/2W	blue-gray-red-gold	146801
	☐ 1	R14	10kΩ 5% 1/2W	brown-black-orange-gold	151001
	☐ 1	R15	22kΩ 5% 1/2W	red-red-orange-gold	152201
	☐ 1	R16	33kΩ 5% 1/2W	orange-orange-orange-gold	153301
	☐ 1	R17	47kΩ 5% 1/2W	yellow-violet-orange-gold	154701
	☐ 1	R18	68kΩ 5% 1/2W	blue-gray-orange-gold	156801
	☐ 1	R19	100kΩ 5% 1/2W	brown-black-yellow-gold	161001
	☐ 1	R20	220kΩ 5% 1/2W	red-red-yellow-gold	162201
	☐ 1	R21	330kΩ 5% 1/2W	orange-orange-yellow-gold	163301
	☐ 1	R22	470kΩ 5% 1/2W	yellow-violet-yellow-gold	164701
	☐ 1	R23	680kΩ 5% 1/2W	blue-gray-yellow-gold	166801
	☐ 1	R24	1MΩ 5% 1/2W	brown-black-green-gold	171001

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Resistors Added

Value	Colors	Part Number
120 ohm	brown-red-brown	CF14JT120RCT-ND
130 ohm	brown-orange-brown	CF14JT130RCT-ND
150 ohm	brown-green-brown	CF14JT150RCT-ND
180 ohm	brown-gray-brown	CF14JT180RCT-ND
200 ohm	red-black-brown	CF14JT200RCT-ND
240 ohm	red-yellow-brown	CF14JT240RCT-ND
270 ohm	red-violet-brown	CF14JT270RCT-ND
390 ohm	orange-white-brown	CF14JT390RCT-ND
430 ohm	yellow-orange-brown	CF14JT430RCT-ND
510 ohm	green-brown-brown	CF14JT510RCT-ND
560 ohm	green-blue-brown	CF14JT560RCT-ND
620 ohm	blue-red-brown	CF14JT620RCT-ND
750 ohm	violet-green-brown	750QBK-ND
820 ohm	gray-red-brown	CF14JT820RCT-ND
910 ohm	white-brown-brown	CF14JT910RCT-ND

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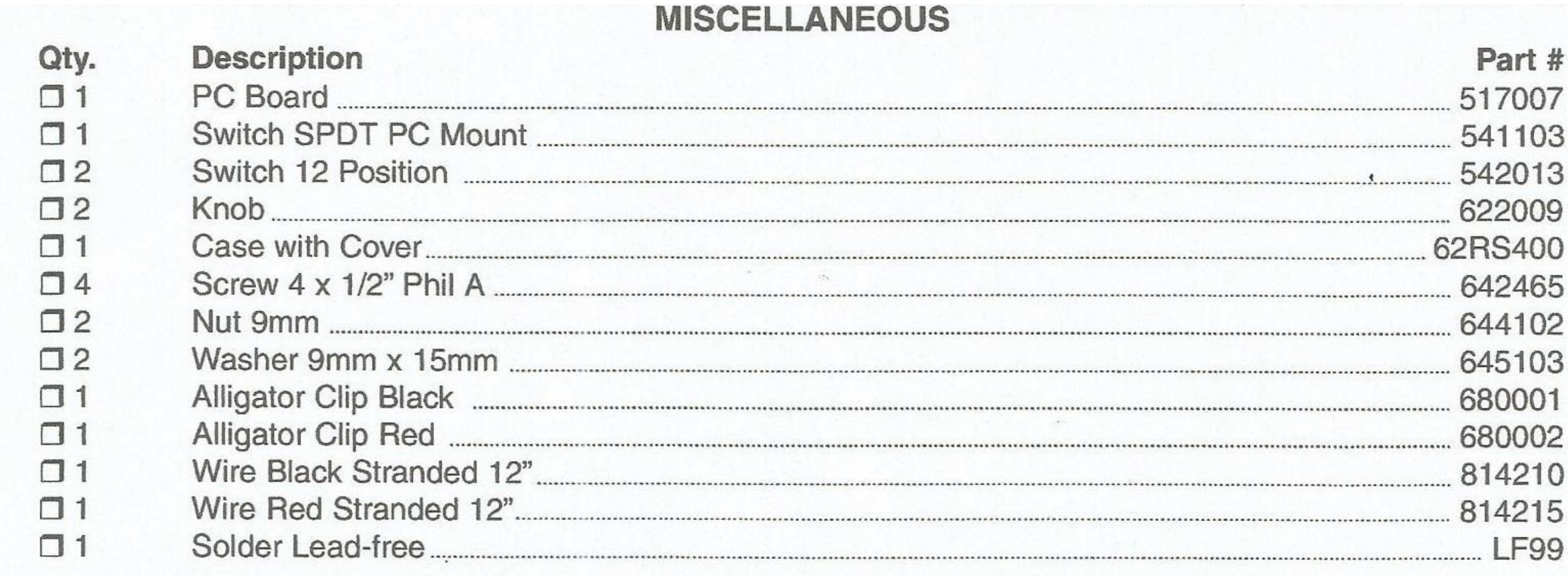
Other parts



MISCELLANEOUS

Qty.	Description	Part #
☐ 1	PC Board	517007
☐ 1	Switch SPDT PC Mount	541103
☐ 2	Switch 12 Position	542013
☐ 2	Knob	622009
☐ 1	Case with Cover	62RS400
☐ 4	Screw 4 x 1/2" Phil A	642465
☐ 2	Nut 9mm	644102
☐ 2	Washer 9mm x 15mm	645103
☐ 1	Alligator Clip Black	680001
☐ 1	Alligator Clip Red	680002
☐ 1	Wire Black Stranded 12"	814210
☐ 1	Wire Red Stranded 12"	814215
☐ 1	Solder Lead-free	LF99

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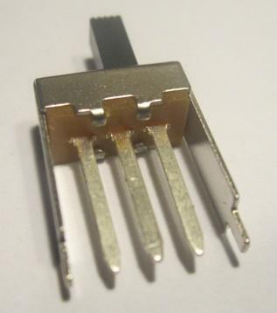
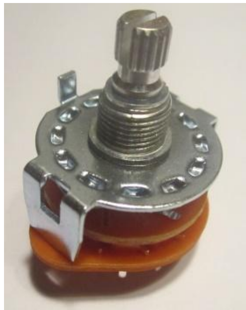
Part Identification

Slide Switch



Rotary Switch

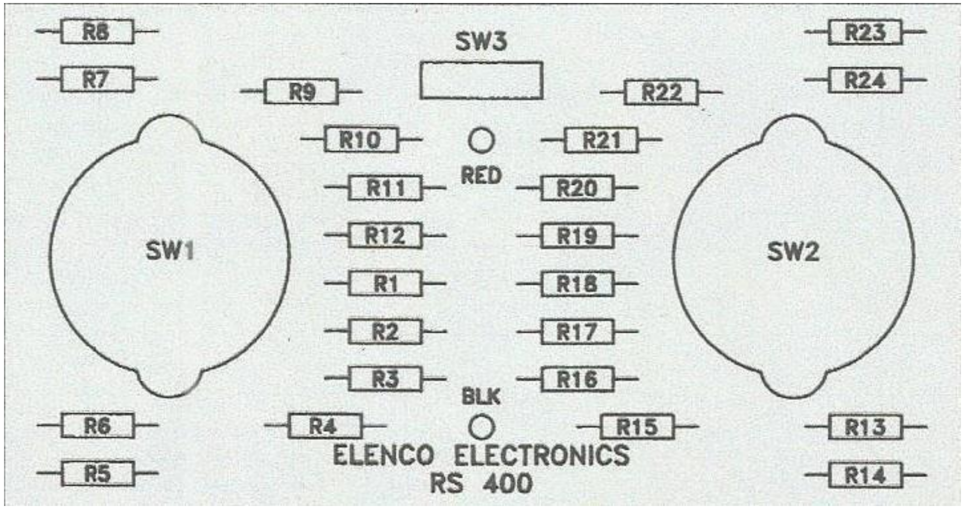


7/16 Nut

Washer

Alligator Clips

PCB



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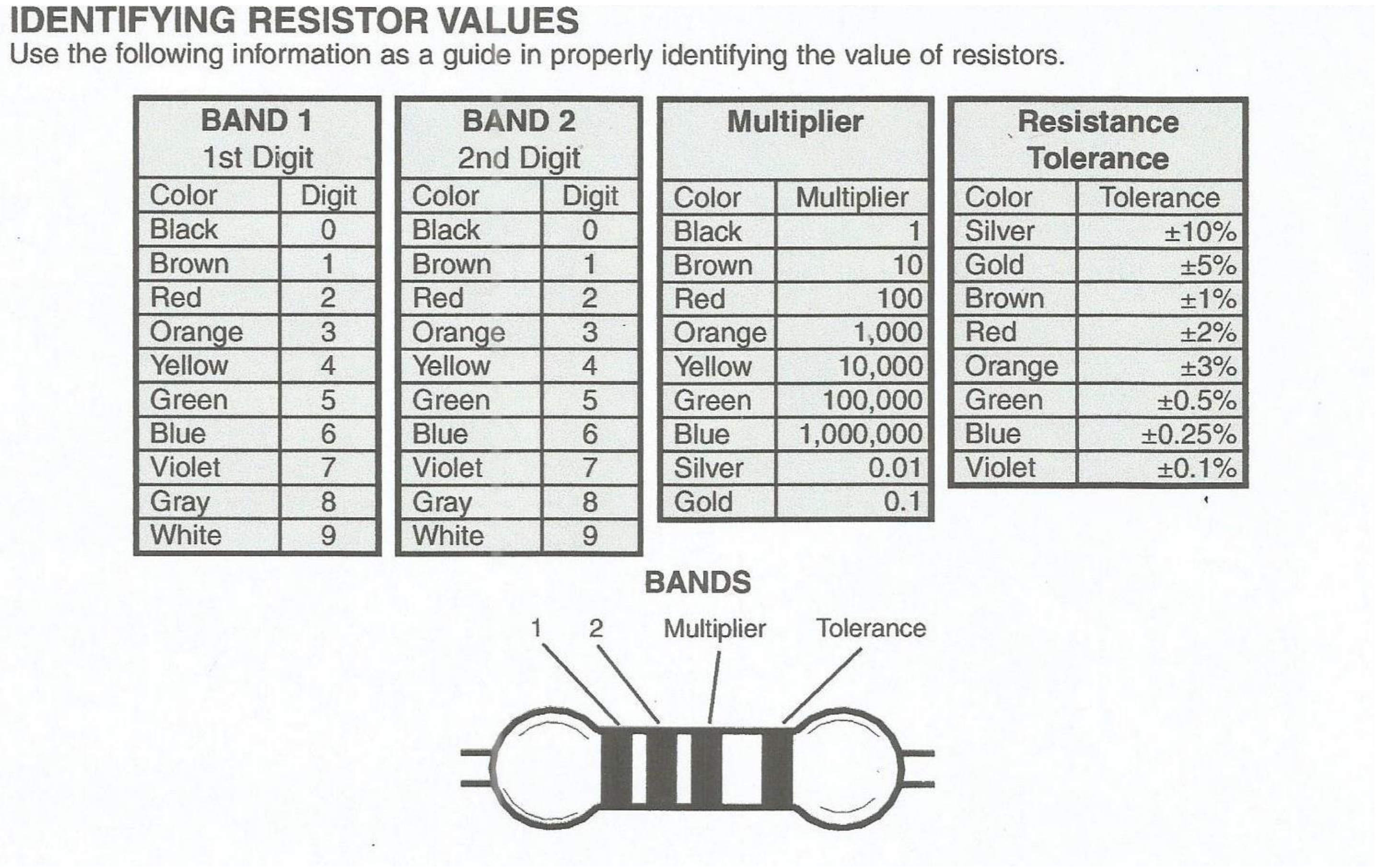

IDENTIFYING RESISTOR VALUES

Use the following information as a guide in properly identifying the value of resistors.

BAND 1
1st Digit

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

BAND 2
2nd Digit

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Multiplier

Color	Multiplier
Black	1
Brown	10
Red	100
Orange	1,000
Yellow	10,000
Green	100,000
Blue	1,000,000
Silver	0.01
Gold	0.1

Resistance Tolerance

Color	Tolerance
Silver	±10%
Gold	±5%
Brown	±1%
Red	±2%
Orange	±3%
Green	±0.5%
Blue	±0.25%
Violet	±0.1%

BANDS

1 2 Multiplier Tolerance

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Solder: Lead vs Lead Free

Lead free solder is supplied in the kit. The properties are:

It contains 99.3% tin, 0.7% copper and a rosin core
It is healthier to use that lead based solder
It has a higher melting point so you need a higher temperature iron
It is more corrosive so it wears out soldering iron tips faster
It takes longer to solder joints due to the excessive heat required
It is harder to protect delicate connections due to overheating
Joints will look duller without the lead present

Solder that contains lead is available if you choose to use it.

Never use acid core solder on electronic circuits

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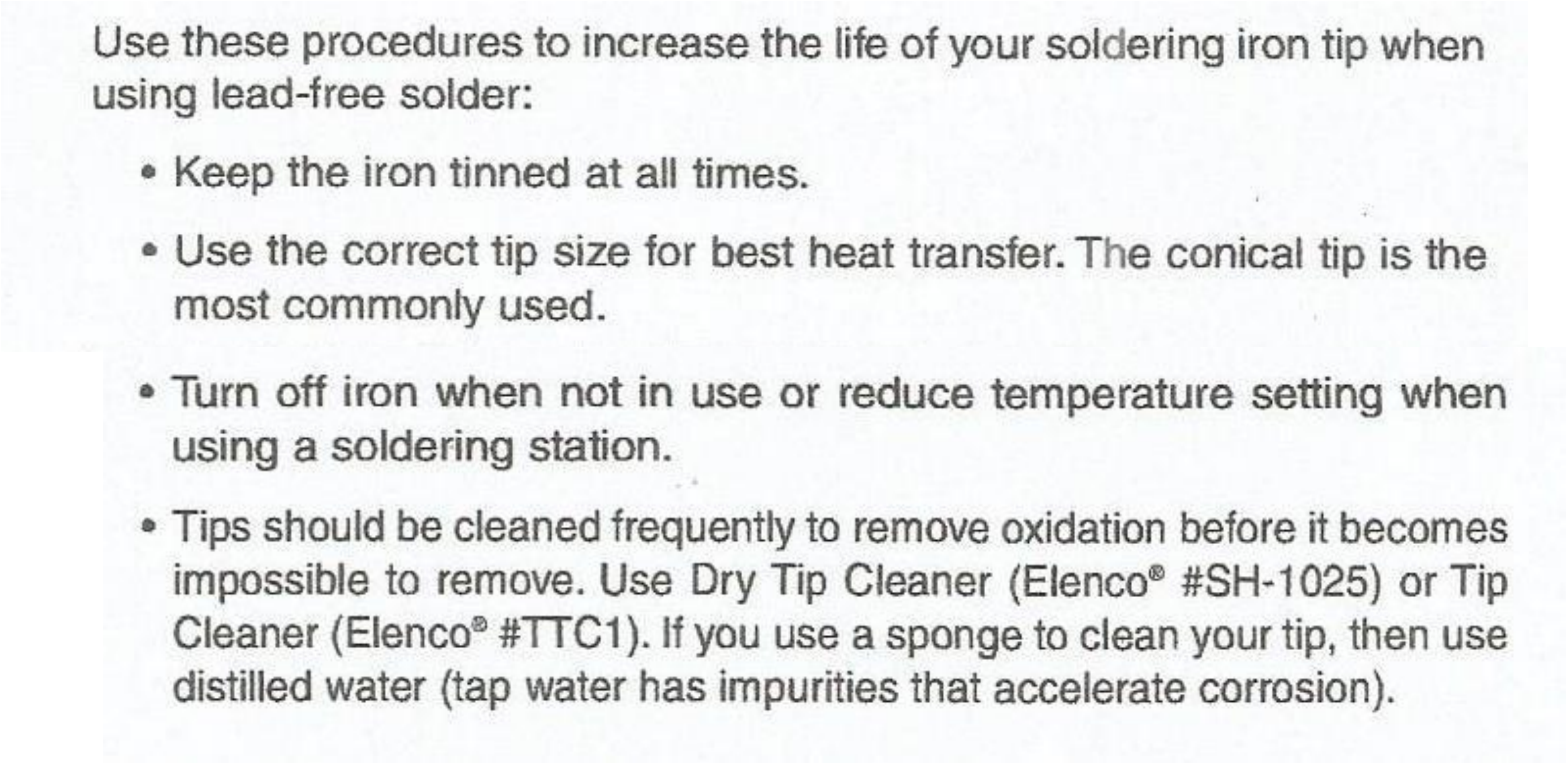
Procedures to use when soldering



Use these procedures to increase the life of your soldering iron tip when using lead-free solder:

- Keep the iron tinned at all times.
- Use the correct tip size for best heat transfer. The conical tip is the most commonly used.
- Turn off iron when not in use or reduce temperature setting when using a soldering station.
- Tips should be cleaned frequently to remove oxidation before it becomes impossible to remove. Use Dry Tip Cleaner (Elenco® #SH-1025) or Tip Cleaner (Elenco® #TTC1). If you use a sponge to clean your tip, then use distilled water (tap water has impurities that accelerate corrosion).

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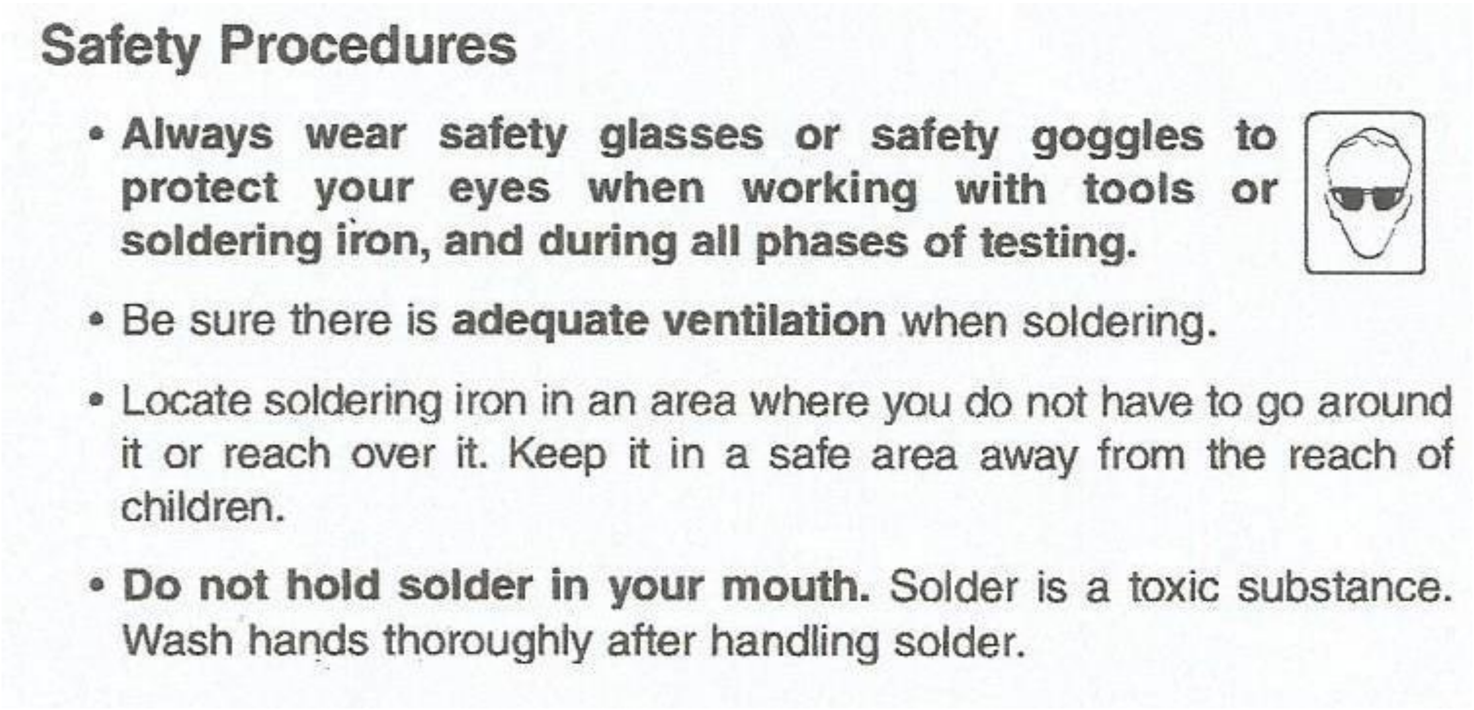
Safety



Safety Procedures

- **Always wear safety glasses or safety goggles to protect your eyes when working with tools or soldering iron, and during all phases of testing.**
- Be sure there is **adequate ventilation** when soldering.
- Locate soldering iron in an area where you do not have to go around it or reach over it. Keep it in a safe area away from the reach of children.
- **Do not hold solder in your mouth.** Solder is a toxic substance. Wash hands thoroughly after handling solder.

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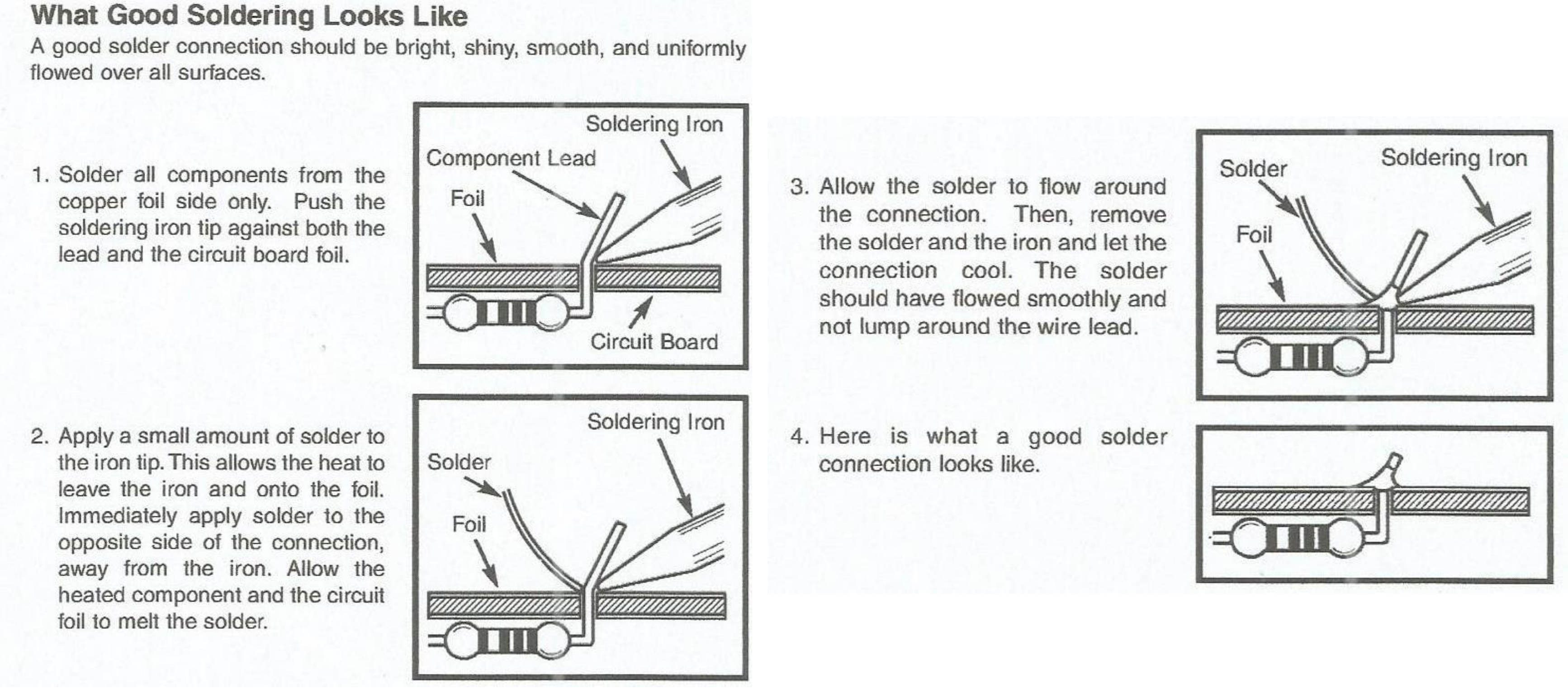
What good soldering joints look like



What Good Soldering Looks Like

A good solder connection should be bright, shiny, smooth, and uniformly flowed over all surfaces.

1. Solder all components from the copper foil side only. Push the soldering iron tip against both the lead and the circuit board foil.

Soldering Iron
Component Lead
Foil
Circuit Board

2. Apply a small amount of solder to the iron tip. This allows the heat to leave the iron and onto the foil. Immediately apply solder to the opposite side of the connection, away from the iron. Allow the heated component and the circuit foil to melt the solder.

3. Allow the solder to flow around the connection. Then, remove the solder and the iron and let the connection cool. The solder should have flowed smoothly and not lump around the wire lead.

4. Here is what a good solder connection looks like.

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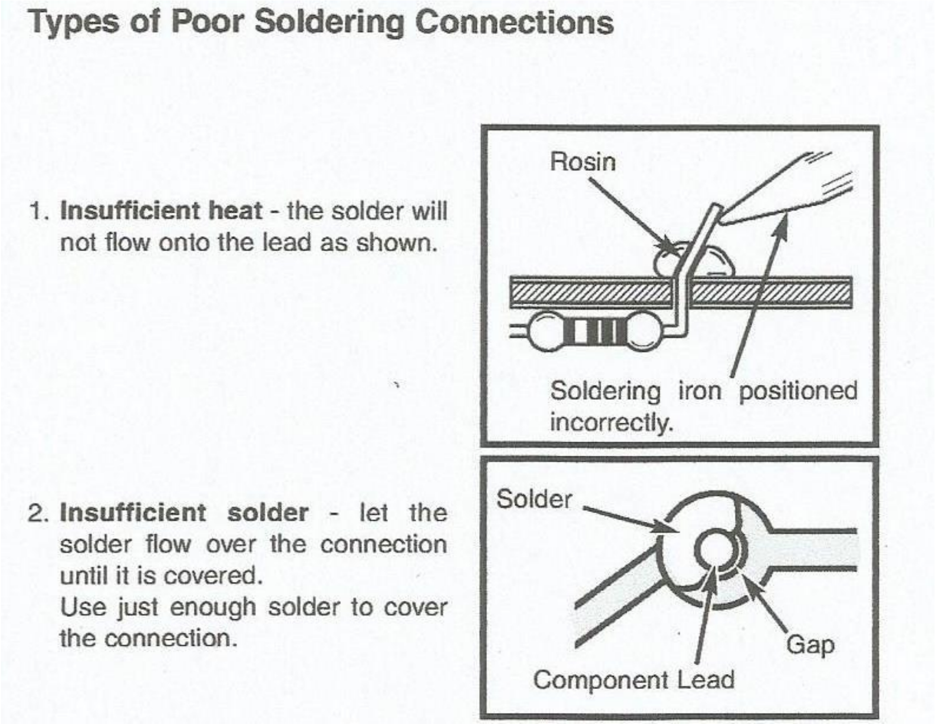
What bad soldering joints look like



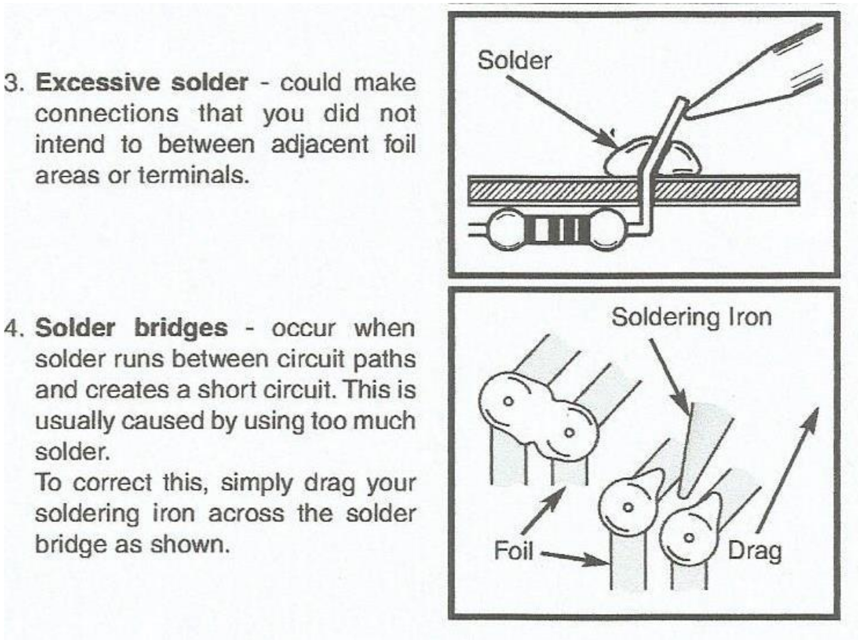
Types of Poor Soldering Connections

1. **Insufficient heat** - the solder will not flow onto the lead as shown.

Rosin
Soldering iron positioned incorrectly.

2. **Insufficient solder** - let the solder flow over the connection until it is covered.
   Use just enough solder to cover the connection.

Solder
Gap
Component Lead



3. **Excessive solder** - could make connections that you did not intend to between adjacent foil areas or terminals.

Solder

4. **Solder bridges** - occur when solder runs between circuit paths and creates a short circuit. This is usually caused by using too much solder.
   To correct this, simply drag your soldering iron across the solder bridge as shown.

Soldering Iron
Foil
Drag

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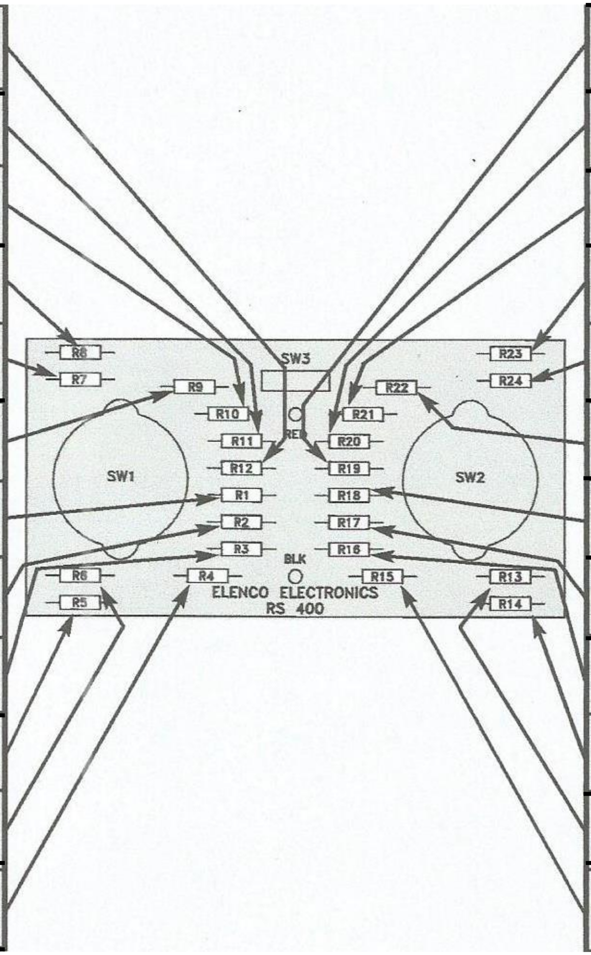

R12 – 430 ohm Yellow-orange-brown

R11 – 390 ohm Orange-white-brown

R10 – 330 ohm Orange-orange-brown

R8 – 240 ohm Red-yellow-brown

R7 – 220 ohm Red-red-brown

R9 – 270 ohm Red-violet-brown

R1 – 100 ohm Brown-black-brown

R2 – 120 ohm Brown-red-brown

R3 – 130 ohm Brown-orange-brown

R5 – 180 ohm Brown-gray-brown

R6 – 200 ohm Red-black-brown

R4 – 150 ohm Brown-green-brown

R19 – 820 ohm Gray-red-brown

R20 – 910 ohm White-brown-brown

R21 – 1K ohm Brown-black-red

R23 – 3.3K ohm Orange-orange-red

R24 – 4.7K ohm Yellow-violet-red

R22 – 2.2K ohm Red-red-red

R18 – 750 ohm Violet-green-brown

R17 – 680 ohm Blue-gray-brown

R16 – 620 ohm Blue-red-brown

R14 – 510 ohm Green-brown-brown

R13 – 470 ohm Yellow-violet-brown

R15 – 560 ohm Green-blue-brown

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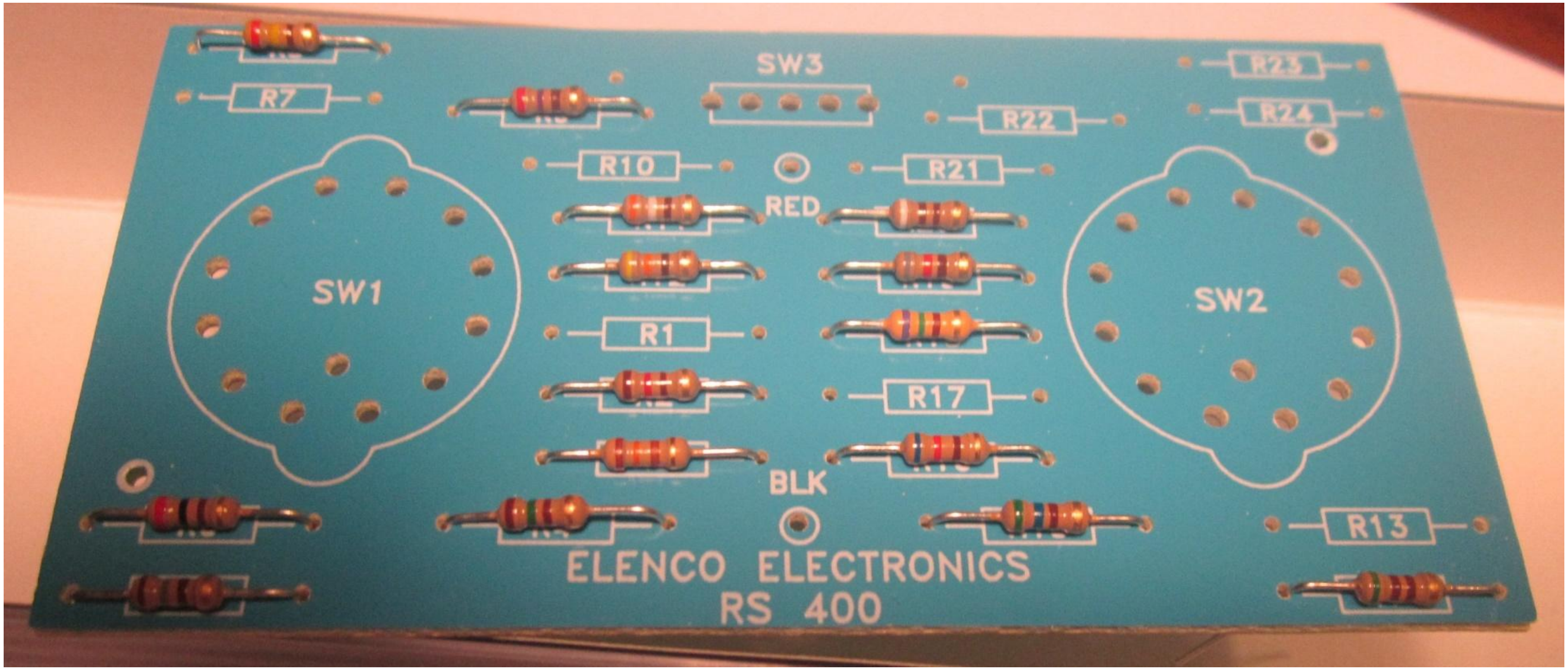
Populating the PCB

Place all of the new resistors in the blank printed circuit board as shown below.



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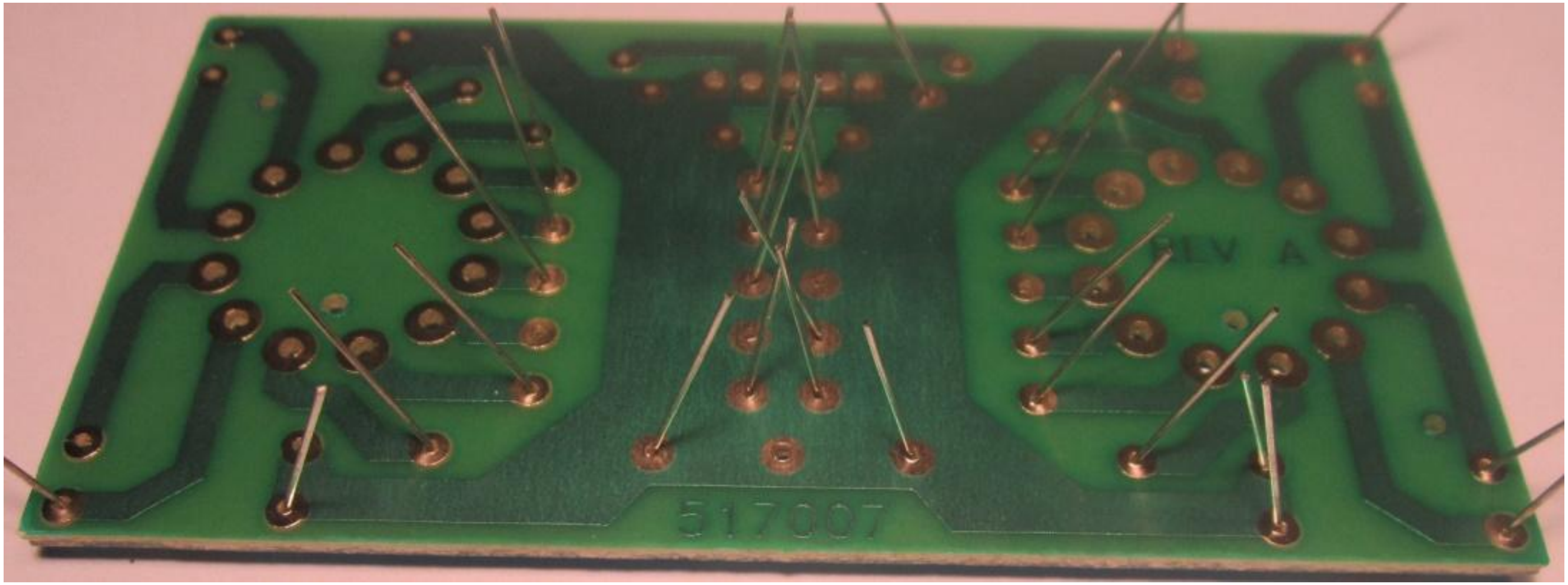
Prepare for soldering

Once all of the new resistors are in place, spread the leads on the pad side slightly to keep them from falling out when the board is flipped over.



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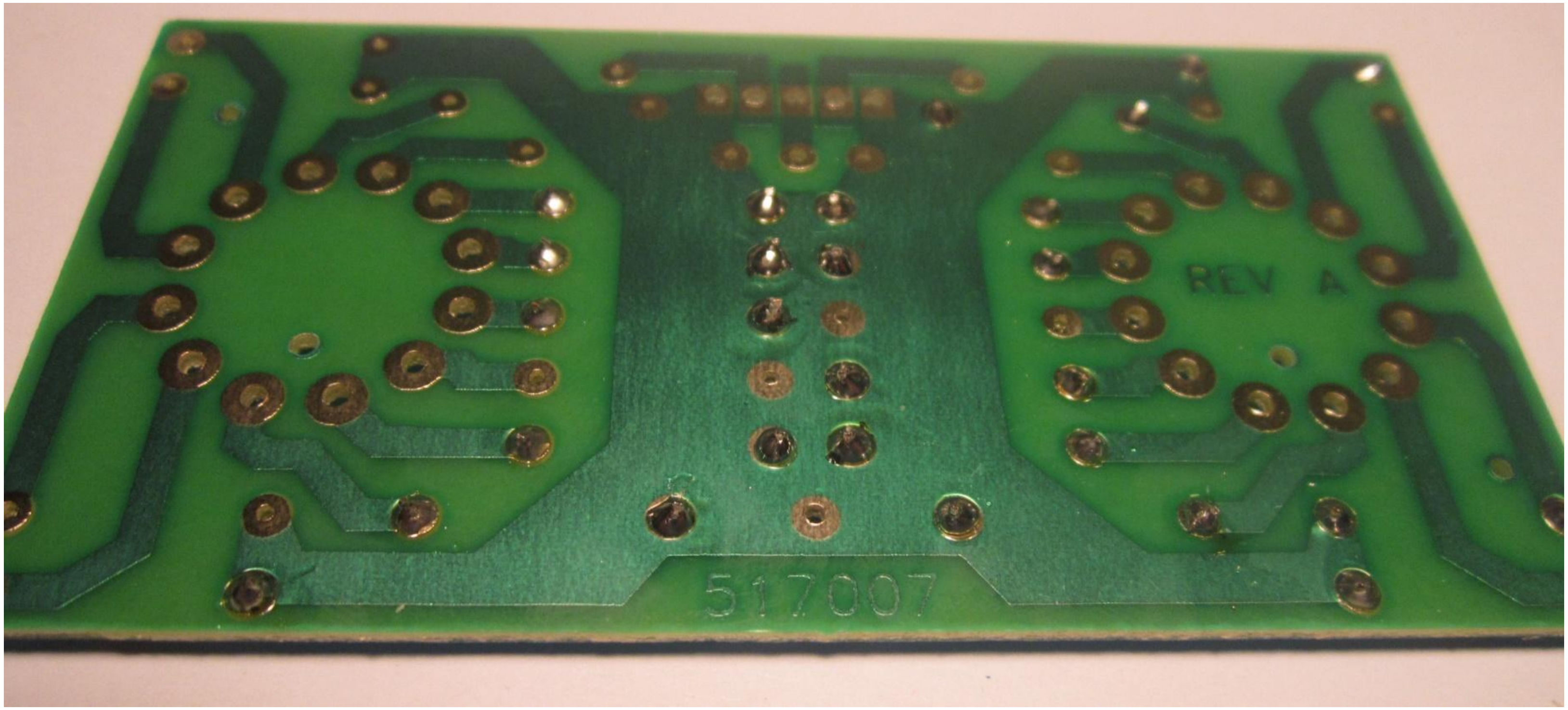
Soldering the resistors

While pressing down on the board, solder all of the leads to the pads. Clip leads off flush with dykes.



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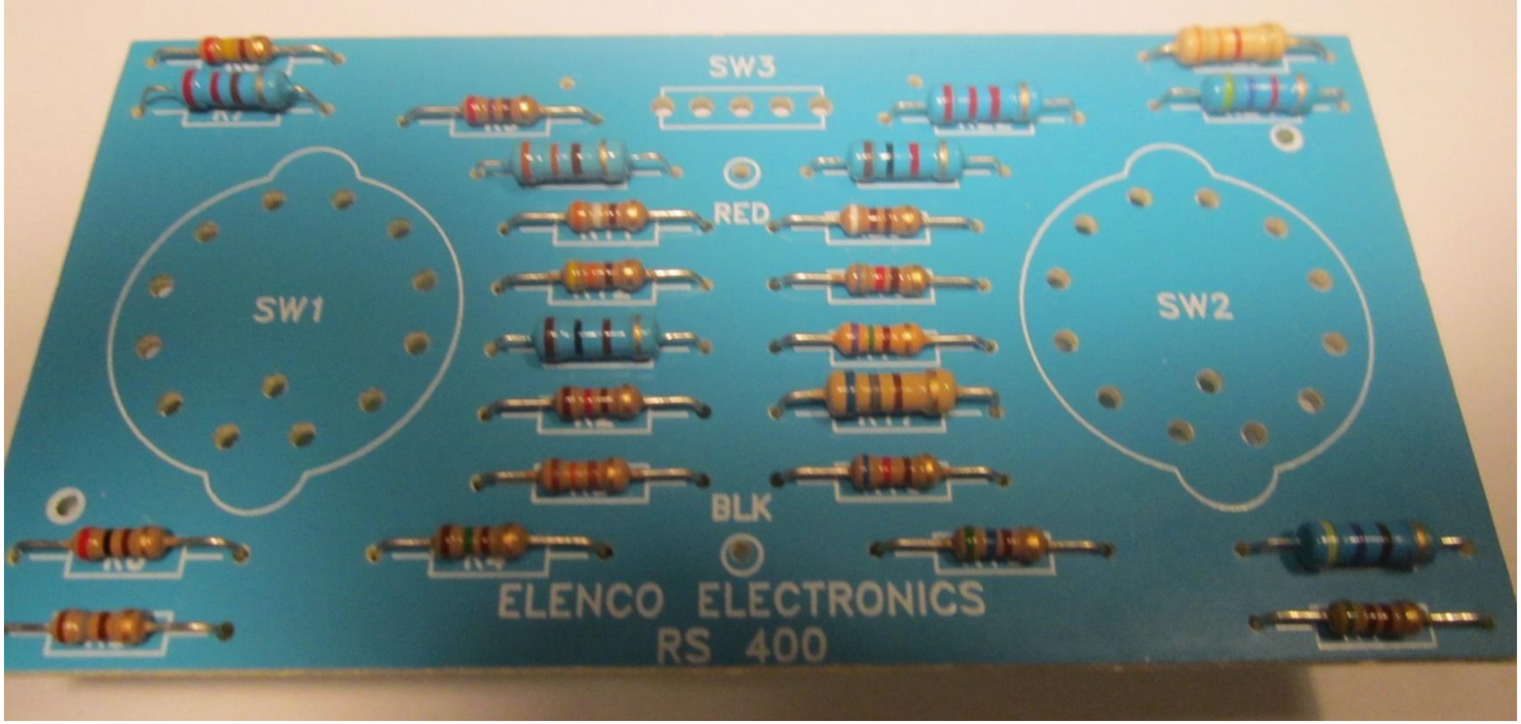
Remaining resistors

Populate the remaining locations with the supplied resistors that were set aside earlier.



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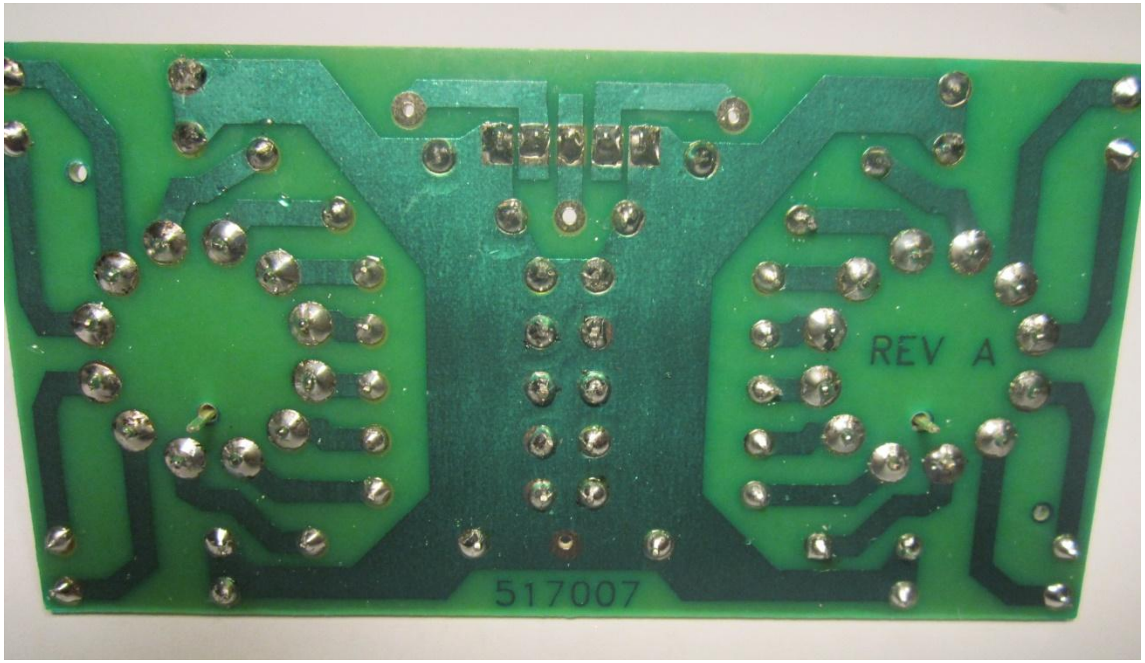
Solder the remaining resistors

Again, spread the leads on the pad side slightly to keep them from falling out when the board is flipped over. Solder all of the leads to the pads and clip the leads off flush with dykes.



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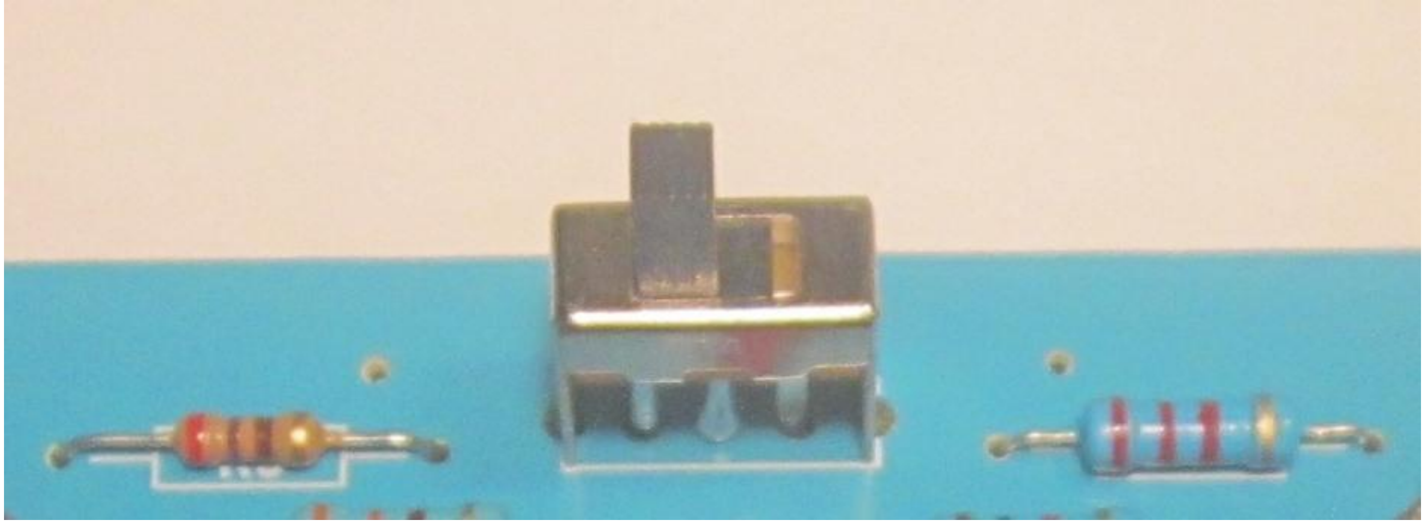
Installing the slide switch

Install the slide switch into the holes labeled S3.



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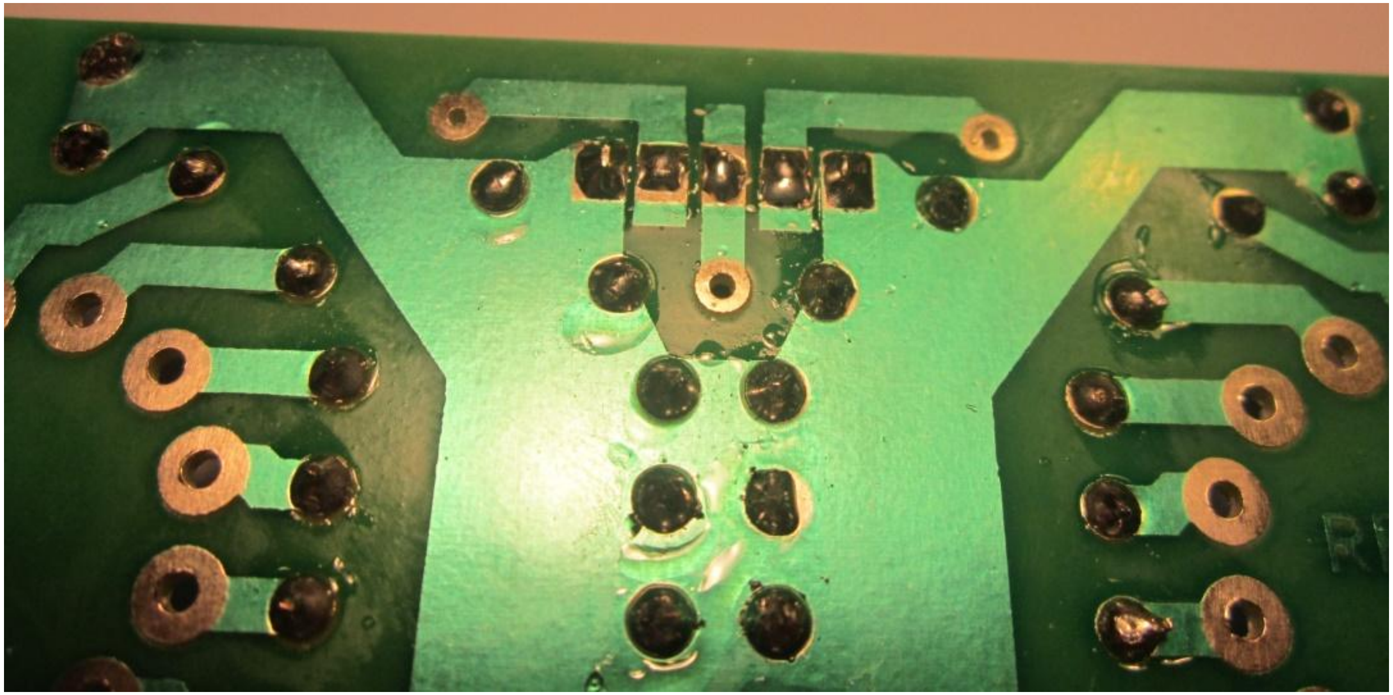
Soldering the slide switch

Flip the board over and make sure the switch is seated flat on the board. Solder the switch in place.



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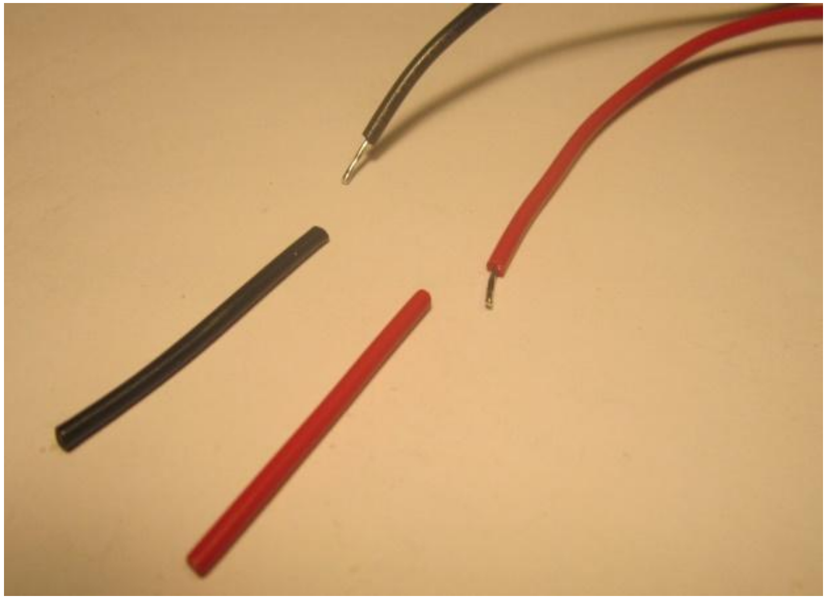
Installing the test leads

Cut off 1-1/2” of wire from one end of the black and red wire supplied and set them aside.
Strip ¼” of insulation from each end of both the long red and black wires. Tin the bare wires.



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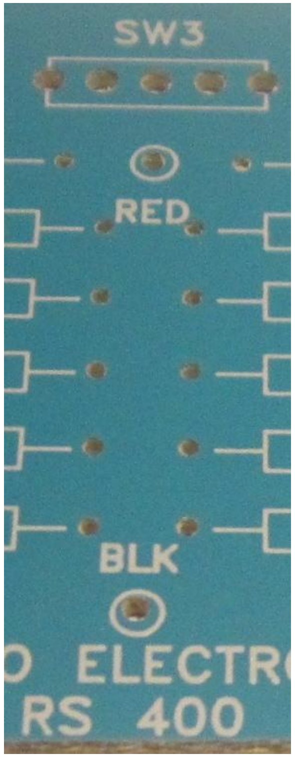
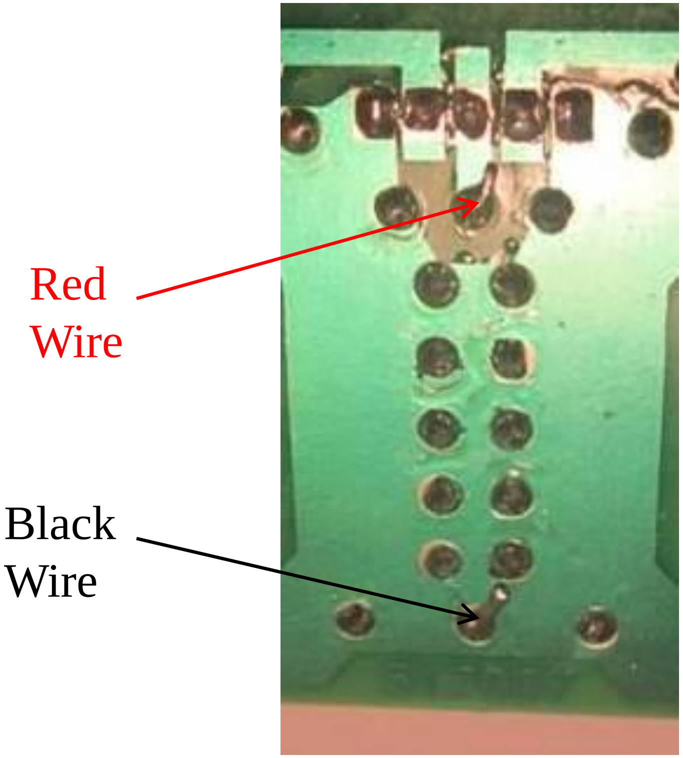
Installing the test leads

Insert the long wires into the holes on the circuit board labeled RED and BLK. Solder the wires into place.




Red Wire

Black Wire

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Installing the test leads

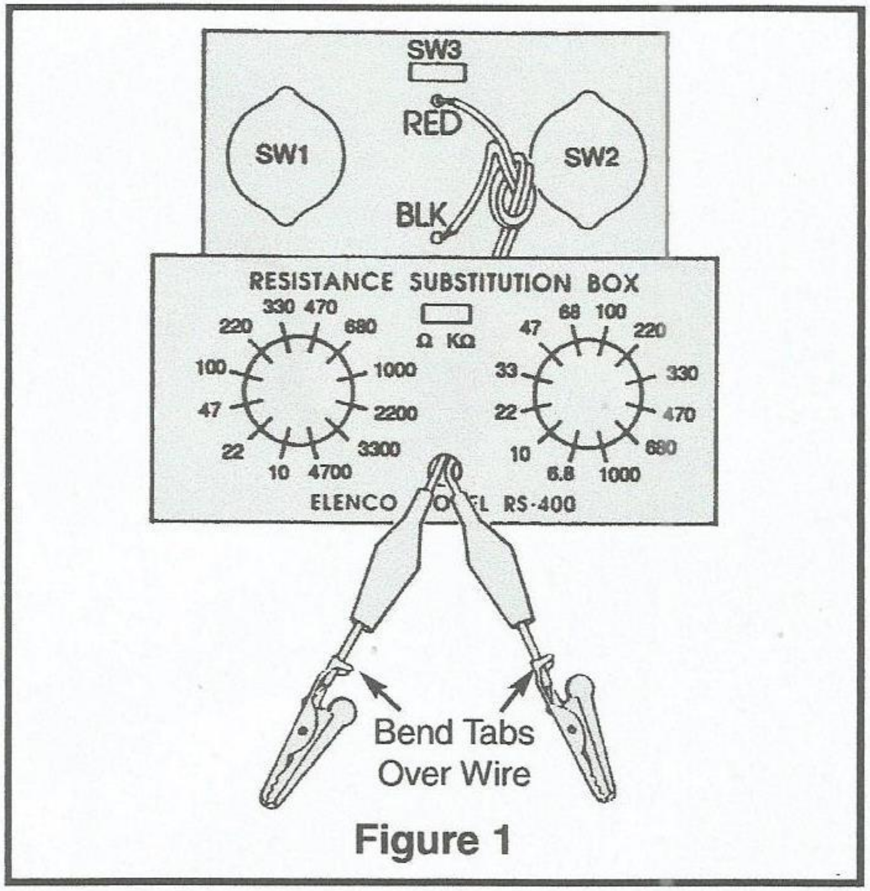

Figure 1

Tie a knot 1-1/2” from the surface of the circuit board.

Pull the wires through the hole in the faceplate.

Slide the alligator boots onto the wires and solder to the alligator clips.

Slide the boots over the clips.

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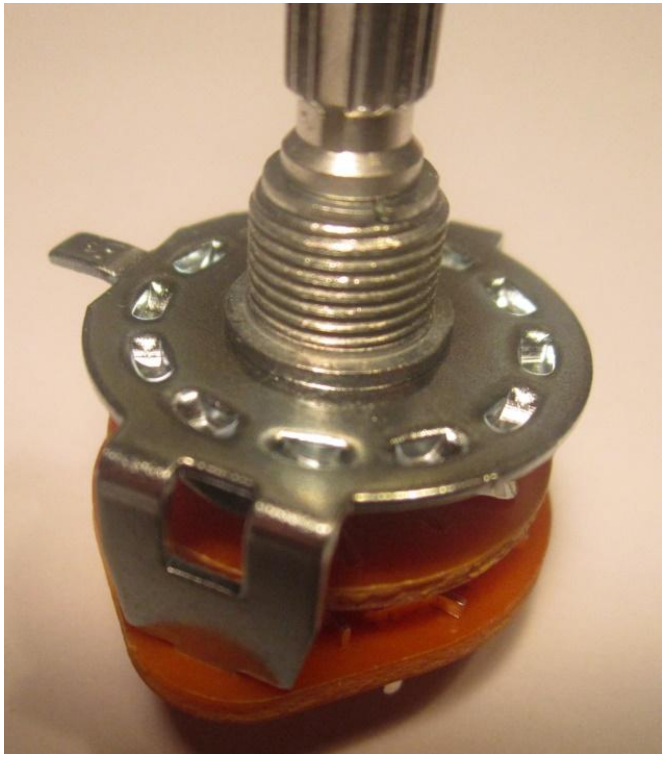
Preparing the two rotary switches

Bend the tab on the switches down.



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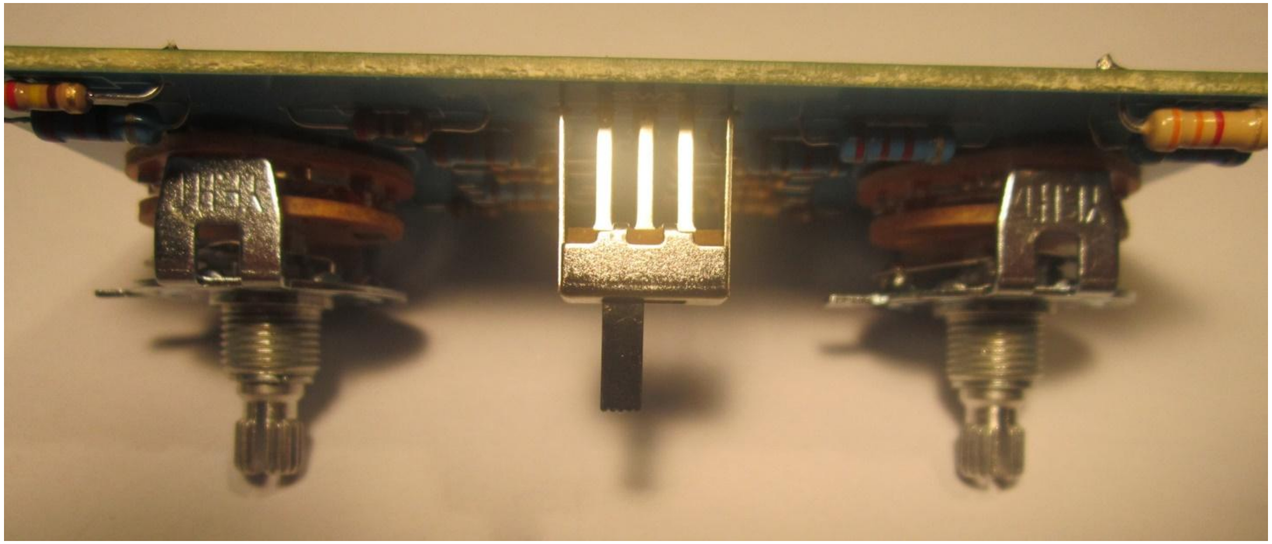
Installing the two rotary switches

Insert both switches into the PCB and tack solder two lugs in place.

Make adjustments to make sure the switches are tight against the board.



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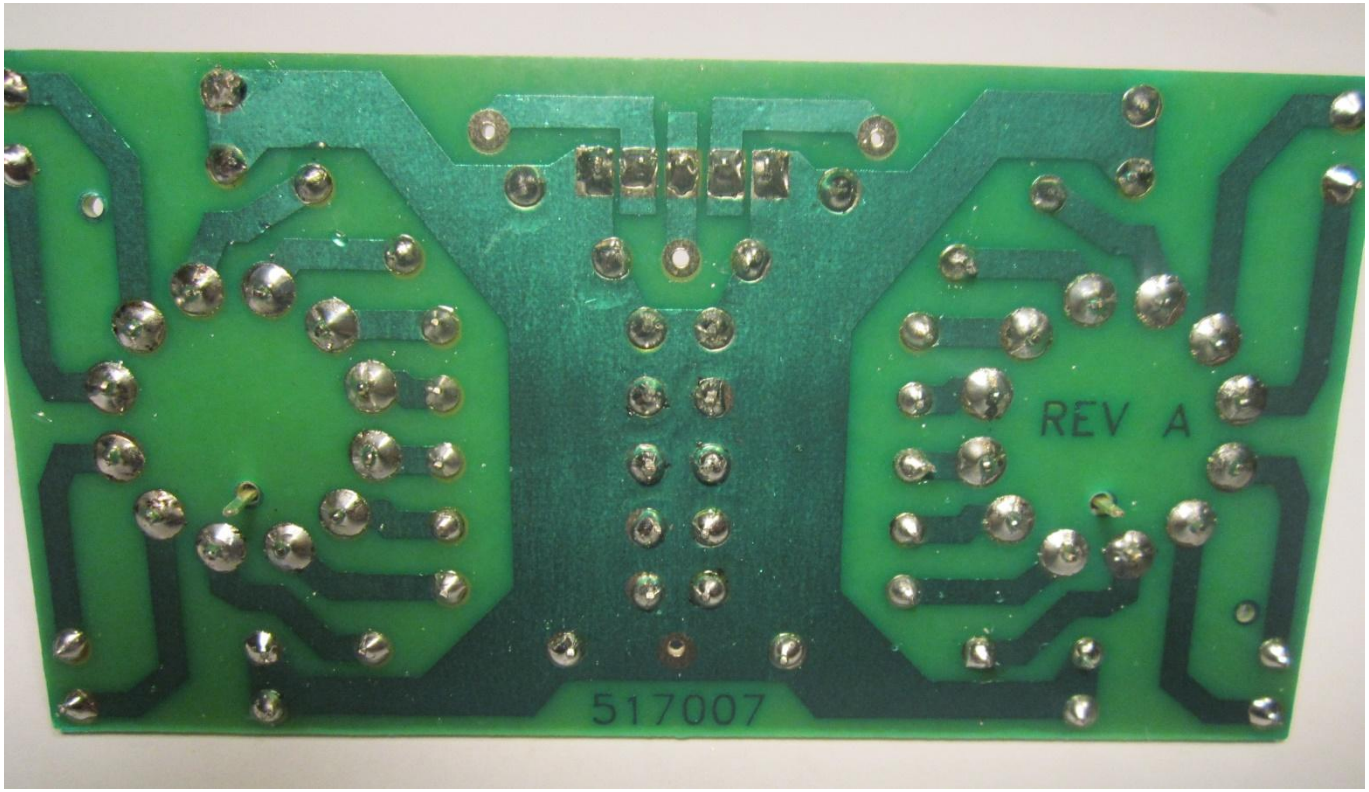
Soldering the two rotary switches

Solder remaining lugs.



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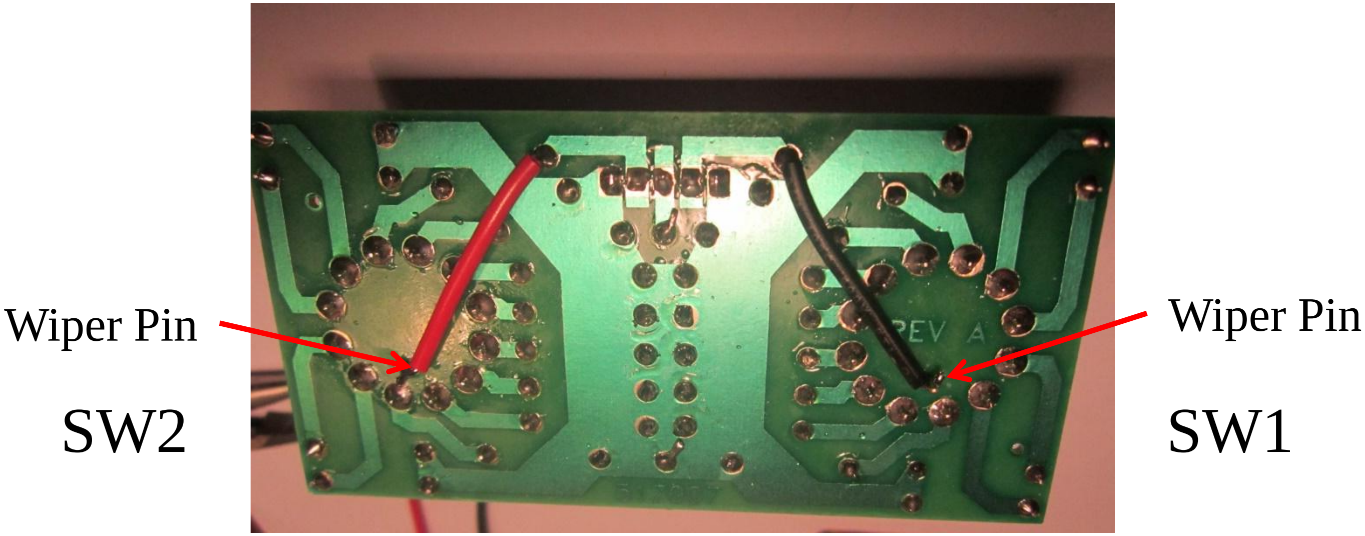
Installing the two jumper wires

- Strip ¼” of insulation from both ends of the red and black wires set aside earlier (1-1/2” wires). Tin the bare wires.
- Solder one end to the wiper pin of the rotary switch and the other to the pad as shown below.



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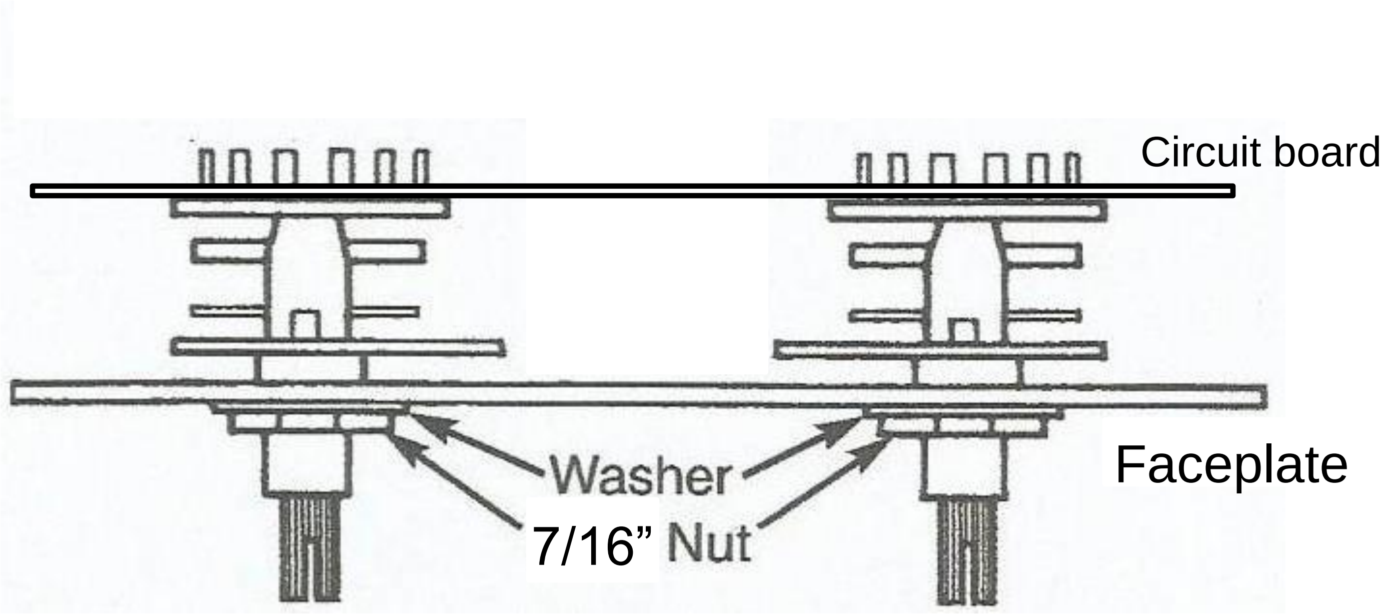
Attaching the faceplate

Attach the faceplate to the switches using the two washers and 7/16” nuts.
Tighten the nuts in place.



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Installing the knobs

- Place the left knob loosely on the left switch post.
- Push the slide switch to the LOW position.
- Connect an ohmmeter to the output leads.
- Line up the pointer on the left knob with the value shown on the meter, then push the knob onto the shaft.

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Installing the knobs

- Place the right knob loosely on the right switch post.
- Push the slide switch to the HIGH position.
- Connect an ohmmeter to the output leads.
- Line up the pointer on the right knob with the value shown on the meter, then push the knob onto the shaft.

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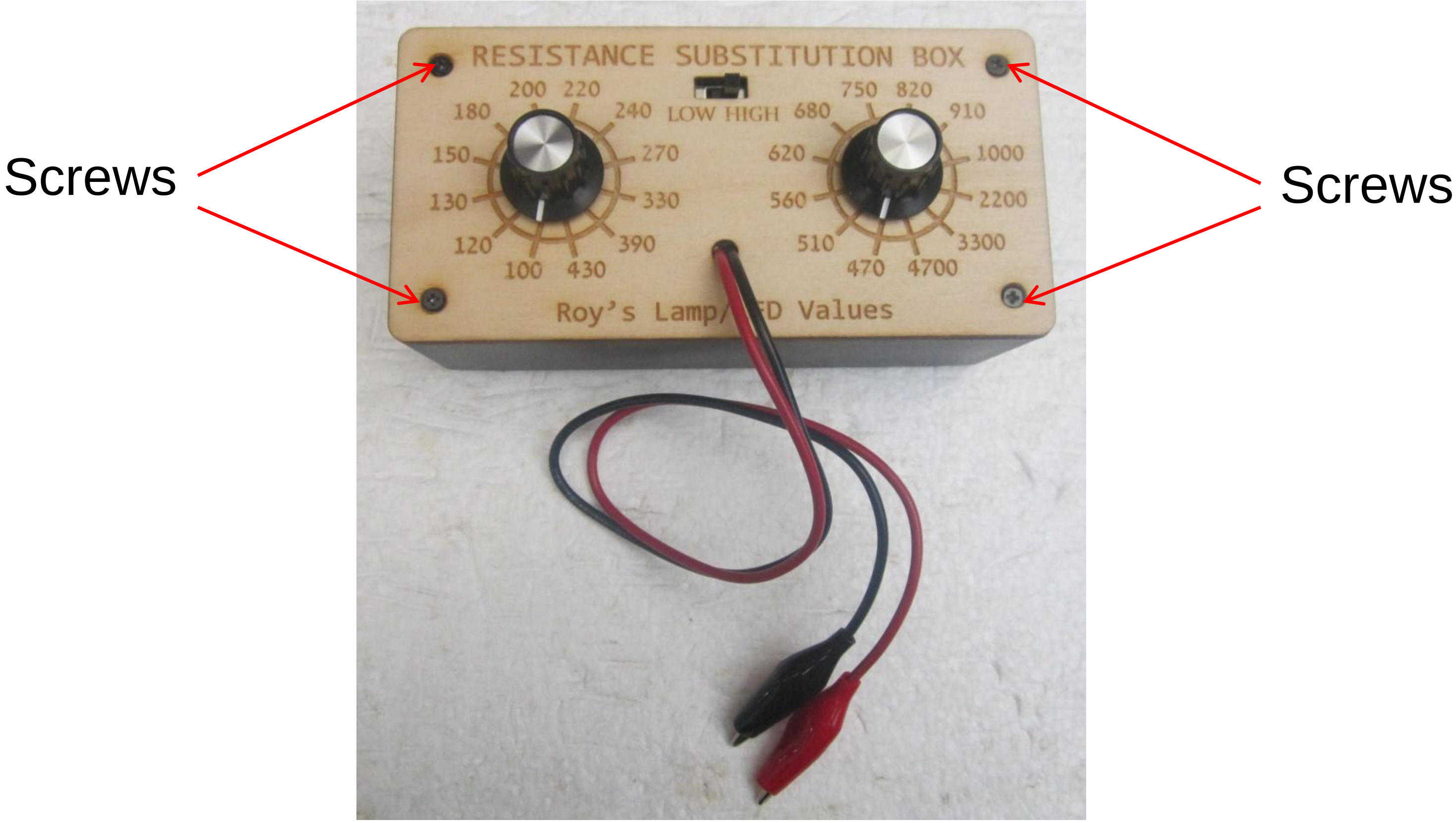
Completing the assembly

Attach the faceplate to the box with the 4 screws provided.



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Testing the box

Use the ohmmeter to test the value of each resistor. The resistors have a tolerance of plus or minus 5%. That means that a 510 ohm resistor could measure between 484.5 ohms and 535.5 ohms and still be correct.

Switch 1 LOW position

Value position	Meter reading
100 OHM	
120 OHM	
130 OHM	
150 OHM	
180 OHM	
200 OHM	
220 OHM	
240 OHM	
270 OHM	
330 OHM	
390 OHM	
430 OHM	

Switch 2 HIGH position

Value position	Meter reading
470 OHM	
510 OHM	
560 OHM	
620 OHM	
680 OHM	
750 OHM	
820 OHM	
910 OHM	
1000 OHM	
2200 OHM	
3300 OHM	
4700 OHM	

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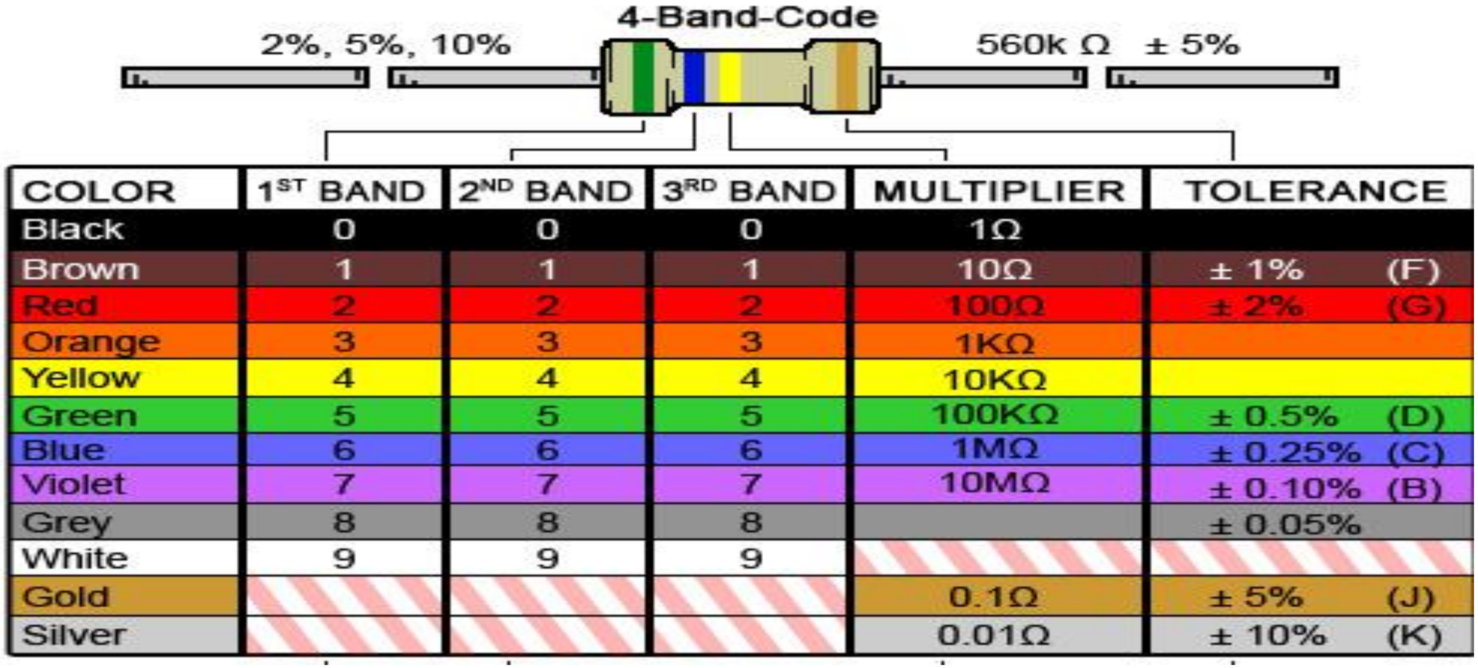
In Conclusion

A full color resistor value chart has been printed on an adhesive backed label and supplied with your kit. You can apply it to the bottom of the box if you desire.


4-Band-Code
2%, 5%, 10%
560k Ω ± 5%

COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

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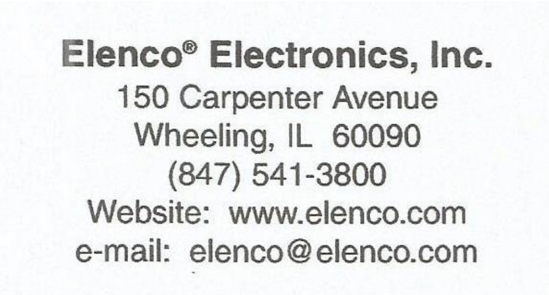

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